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PLANT BUGS OF *QUERCUS ILICIFOLIA:* MYRIADS OF MIRIDS (HETEROPTERA) IN PITCH PINE-SCRUB OAK BARRENS

A. G. Wheeler, Jr.

Bureau of Plant Industry, Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania 17110

Abstract.—An inventory of the Miridae associated with scrub (bear) oak, *Quercus ilicifolia* Wangenh., was conducted in northeastern pitch pine-scrub oak barrens and related natural communities from Maine to Virginia, nearly the complete range of this plant. Samples were taken throughout the season in an extensive pine barren near Frackville, northeastern Pennsylvania. Accounts of the 44 species collected (33 at Frackville) include a review of known distribution and biology, new state records obtained during the study, and data on seasonal history and habits on scrub oak. Three patchily distributed, rarely collected antlike (myrmecomorphic) mirids were discovered: *Pilophorus furvus* Knight, *Schaffneria davisi* Knight, and *S. schaffneri* Knight. These were collected only in or near aphid colonies tended by the ant *Dolichoderus taschenbergi* (Mayr), and they may be Batesian mimics gaining protection from predators because of their resemblance to ants.

The rich fauna of *Q. ilicifolia* consists of phytophagous and predacious mirids, including early-season specialists on staminate catkins, and appears to be more diverse than that occurring on some larger (canopy) oak species. Faunal composition varied among the communities inventoried and, at a given site, changed with seasonal progression. Species richness was greatest in larger pine barrens; few Miridae were collected in remnant pine barrens or in most ridgetop barrens. Several plant bugs are abundant on (but not restricted to) scrub oak, and may be considered indicator species of pine barrens and similar communities.

> How much do we know about life on this little-known planet beneath our feet, the planet earth? We have not even approached the end of cataloguing the creatures that share the earth with us: and this should be the very first step in our knowledge.
>
> —H. E. Evans, *Life on a Little-known Planet,* 1966

Oaks, *Quercus* spp. (Fagaceae), are noted for a rich insect fauna (e.g., Jones, 1959; Southwood, 1960; Elton, 1966; Morris, 1974; Opler, 1974a). Connold (1908), for example, referred to the "vast concourse of dependents" inhabiting British oaks. In addition to such explicit statements, insect diversity of oaks is implicit from host lists of various groups, for instance, those of Patch (1938) for North American aphids and Tietz (1972) for macrolepidoptera. Species richness in North America is particularly developed among cynipid wasps (Felt, 1940; Houard, 1940) and microlepidoptera (Opler, 1974a, b). But great insect diversity (used in the context of numbers of species or richness, not in a strict statistical sense) probably characterizes oaks in all regions with fagaceous forests: eastern and western North America (oaks reach maximum concentration in the Sierra Madres of Mexico), Europe, and Asia (including tropical montane forests).

Among Heteroptera, or true bugs, the diverse mirid fauna associated with oaks in Great Britain and continental Europe is well known (Butler, 1923; Southwood and Leston, 1959; Ehanno, 1965, 1987; Strawinski, 1974; Goula, 1986). Including several plant bugs of presumed accidental occurrence, the fauna collected on *Q. robur* L. in France numbered 36 species; 19 mirids occurred regularly on this plant (Ehanno, 1965).

Miridae associated with North American oaks have received less attention than in Europe, although the number of species known to occur on *Quercus* is considerable (Knight, 1941, 1968; Kelton, 1980). Information on oak plant bugs in North America is mainly limited to lists of species from particular regions, e.g., Illinois (Knight, 1941), and accompanying biological notes; host data cited in taxonomic works treating genera that contain oak-associated species, e.g., *Atractotomus* (Stonedahl, 1990), *Ceratocapsus* (Henry, 1979), *Phytocoris* (Stonedahl, 1988), *Pilophorus* (Schuh and Schwartz, 1988), and *Reuteria* (Henry, 1976); and ecological studies of oak specialists such as *Pseudoxenetus regalis* (Uhler) (Blinn, 1988). In addition, Bray and Triplehorn's (1953) study of insects found on pin oak (*Quercus palustris* Muenchh.) and northern red oak (*Q. rubra* L.) in Delaware includes records of more than 20 mirids, although about half the species should be considered merely incidental on oak. Studies of the plant bug fauna on particular oak species are lacking for North America.

In the mid- to late 1970s, collections from *Q. ilicifolia* Wangenh. in the pine barrens near Frackville, Pennsylvania, suggested that scrub oak harbored a richer plant bug fauna than many tree oaks. Presented here are the results of several years' sampling at this site and an inventory of the mirid fauna of this plant in other areas, mainly northeastern pitch pine-scrub oak barrens. A diverse biota, including endemic rare, threatened, or endangered Lepidoptera, characterizes this globally threatened community type. The requisite conditions of strongly acidic, nutrient-poor soils and natural wildfires rarely occur (Cryan, 1985). Because of fire suppression, housing and industrial development, and other threats, fewer than 20 major pine barrens remain from once extensive occurrences (Cryan, 1985; Schweitzer and Rawinski, 1986). Habitat deterioration is evident in extant barrens (Kerlinger and Doremus, 1981a, b; Schweitzer and Rawinski, 1986; Widoff, 1987).

I am pleased to dedicate this paper to Dr. James A. Slater, world authority on the Heteroptera and respected researcher, teacher, and administrator. Although he became a specialist in the Lygaeidae, he intended to concentrate on Miridae (see Slater, 1978). His early work thus includes several important studies on this group. His encouragement of my biological work on mirids and other Heteroptera, dating from my graduate student years at Cornell University, is genuinely appreciated.

In addition, it seems appropriate here to acknowledge the exemplary efforts of The Nature Conservancy in protecting rare natural communities and species and in helping preserve biodiversity. This paper also is dedicated to TNC and its network of State Natural Heritage Programs, especially to those Heritage and Conservancy staff members who have encouraged and facilitated my faunal inventory work.

STUDY SITES AND METHODS

Description of the natural community. Pine barrens designates a vegetational pattern consisting of open pitch pine (*Pinus rigida* Mill.) forests having an understory

Fig. 1. Pitch pine-scrub oak barrens at Long Pond, Pennsylvania (courtesy Pennsylvania Science Office of The Nature Conservancy).

of heaths and shrubby oaks (Fig. 1). Because the canopy is closed in few places, pine barrens communities technically are woodlands rather than forests (Rawinski, 1987). The name pine barrens, dating from Colonial times, was given to land that would not produce crops and that supported sheep laurel and other plants poisonous to livestock (Cryan, 1985). Sometimes called "devil's land" (Cryan, 1985), pine barrens appear to some as "a sorry collection of small, shrubby, and crowded trees" (Jorgensen, 1978). To others, these bleak wastelands hold a special attraction: "Wastelands [pine barrens], to me, oftentimes seem the least of all wasted" (Teale, 1963).

These shrub-savannah communities (Reschke, 1990) are found in the eastern United States from New Jersey to southern Maine (Olsvig et al., 1979). The well-known New Jersey Pine Barrens sometimes are excluded from the northeastern pitch pine-scrub oak barrens (synonyms of this community type are oak brush plains and pine bush). Because the New Jersey Pine Barrens have a more southern flora, a mosaic of vegetation types unlike those of northeastern pitch pine-scrub oak barrens, and a richer lepidopteran fauna, they may be considered a somewhat different natural community (Schweitzer and Rawinski, 1986). Although pine barrens is a more general term that includes related communities (Whittaker, 1979) such as pitch pine-heath barrens (which lack scrub oaks), this shortened form will be used occasionally in this paper to refer to northeastern pitch pine-scrub oak barrens.

Pine barrens generally occur on sandy, excessively well-drained, nutrient-poor soils. They occur on rolling terrain (but are sometimes flat) ranging from sand dunes to glacial till and outwash plains. Hot by day, barrens experience rapid radiational

cooling at night; depressions in the terrain result in frost pockets that in spring may kill partially expanded foliage of scrub oak. Late-season killing frosts may almost eliminate scrub oak from these depressions (Rawinski, 1987).

In these multilayered communities, pitch pine usually dominates a sparse, interrupted canopy (about 8–16 m high). Scrub oak, *Quercus ilicifolia,* and dwarf chestnut (or dwarf chinkapin) oak, *Q. prinoides* Willd., make up most of the tall shrub layer (about 2–3 m high), often forming a nearly continuous tall shrub canopy. A low shrub layer (0.5 m high or less) consisting of various ericaceous plants (mainly species of *Gaylussacia, Kalmia,* and *Vaccinium*), sweetfern [*Comptonia peregrina* (L.) Coult.], and others is found beneath the tall shrubs and in openings in between. Herbaceous plants account for relatively little biomass but may be present in openings between shrubby thickets. The composition of these grasses and forbs, and their proportion in the community, vary between barrens. Little bluestem [*Schizachyrium scoparium* (Michx.) Nash] often is the dominant grass (Schweitzer and Rawinski, 1986; Widoff, 1987).

Pine barrens are disclimax, fire-dependent communities. They are prone to fire because the underlying sands are rapidly permeable and because high soil acidity retards microbial decomposition of organic matter, which leads to accumulation of a thick layer of duff (Rawinski, 1987). Fires every 6 to 15 years are typical, and a frequency of at least every 15–20 years may be needed to maintain certain pine barrens, that is, to prevent succession to northern mixed forest or other deciduous forest types (Kerlinger & Doremus, 1981a; Cryan, 1985). The frequency necessary for maintenance, however, varies between sites. Where this frequency is low, hardwood trees such as gray birch (*Betula populifolia* Marsh.), aspen (*Populus* spp.), black oak (*Quercus velutina* Lam.), and scarlet oak (*Q. coccinea* Muenchh.) may invade (Schweitzer and Rawinski, 1986; Reschke, 1990).

Several subtypes of pine barrens have been recognized (Schweitzer and Rawinski, 1986). A boreal variant occurs in northern hardwood-spruce-fir regions (northern New York, Maine, and parts of New Hampshire). Various northern herbs are present, but *Q. prinoides* and certain other plants characteristic of more southern pine barrens are absent. In the middle latitudes an inland variant is characterized by colonies of plants such as wild lupine (*Lupinus perennis* L.), New Jersey tea (*Ceanothus americanus* L.), and false indigo [*Baptisia tinctoria* (L.) R. Br.]; examples are the Albany Pine Bush and sites in western Massachusetts, southern New Hampshire, and Rhode Island. Long Island, N.Y., and Cape Cod, Mass., are examples of a coastal variant having an ocean-influenced, moderated climate; these sites have plants such as *Hudsonia* spp. and southern species of Lepidoptera. Barrens in northeastern Pennsylvania, a Poconos variant, have associated wetlands. Fly poison [*Amianthium muscaetoxicum* (Walt.) Gray], rhodora [*Rhododendron canadense* (L.) Torr.], and variable sedge, *Carex polymorpha* Muhl., are present, but plants such as wild lupine and New Jersey tea are absent. Some barrens, such as Scotia in central Pennsylvania (see description of study sites), do not fit any of the above categories (Schweitzer and Rawinski, 1986).

In addition to a distinctive flora, pine barrens are characterized by the presence of animals that do not occur in nearby deciduous forest communities (Cryan, 1980). The New Jersey Pine Barrens (Boyd, 1973) and the Albany Pine Bush (Rittner, 1976) have long been favored collecting grounds for entomologists. Except for Lepidoptera, however, and a few groups such as tiger beetles (Boyd, 1973) and cerambycids

(McCabe and Huether, 1986), the insect fauna of most northeastern pine barrens has not been intensively studied. Characteristic lepidopterans in this community type are the buck moth, *Hemileuca maia* (Drury), a saturniid nearly restricted to feeding on shrubby oaks, mainly *Q. ilicifolia* (Cryan and Dirig, 1975, 1977; Cryan, 1985), and the Karner blue, *Lycaeides melissa samuelis* Nabokov, a lycaenid butterfly that specializes on wild lupine (Dirig, 1976, 1988; Stewart and Ricci, 1988).

Similar, but floristically different, pitch pine-scrub oak associations occur on acidic rocky summits and outcrops (Harshberger, 1911). These ridgetop barrens usually are not as extensive as those in lowland areas. An exception is the Shawangunk Mountains in southeastern New York (see Study sites). Other similar associations are the dwarf pine plains of Long Island, heathlands such as those on Nantucket Island and Martha's Vineyard in Massachusetts (Olsvig, 1980), some serpentine barrens in Maryland and Pennsylvania (Pennell, 1910) and shale barrens of the mid-Appalachians (Platt, 1951), and dry ridges in the southern Appalachians (Schweitzer and Rawinski, 1986).

The host plant. Scrub oak, or bear oak as it is known to foresters (Eyre, 1980), is a scraggly shrub or small round-topped tree belonging to the red oak (subgenus *Erythrobalanus*) group. The numerous tough, crooked, interlacing branches help identify this plant (Brown, 1938). The only other oak likely to be confused with it is the shrubby *Q. prinoides,* which may occur with *Q. ilicifolia* and which locally may also be called scrub oak. It, however, belongs to the white oak group (subgenus *Lepidobalanus*) and can be distinguished by leaves that lack bristle-tipped lobes, a flaky rather than nearly smooth bark, more smooth twigs, more blunt buds, and larger fruit having nut and cup of different form.

Capable of attaining 7–8 m on fertile soil, *Q. ilicifolia* often grows only 1–2 m high. It is especially common on acidic (optimum pH is 4.5 to 6.0), droughty, sterile soils—and thus characteristic of dry sand barrens and rocky hillsides. Scrub oak is shade intolerant, and frequently forms dense, nearly impenetrable thickets. After fire, cutting, or routing, it sprouts vigorously from strong roots and a gnarled, twisted crown (Brown, 1938; Pa. Dep. For. Waters, 1951; Wolgast, 1974). Twenty or more shoots may appear in one clump, and single-stemmed plants have produced as many as 40 stems (Worley et al., 1957).

Quercus ilicifolia usually is said to occur from sea level to an elevation of only 900 m (Eyre et al., 1954), but it is known from about 1,330 m on Panther Knob in West Virginia (Harmon, 1981). Scrub oak ranges from southern Maine through much of southern New England to eastern New York (mainly on Long Island and in the Hudson River valley) and eastern and southwestern Pennsylvania, and south to eastern West Virginia and western Virginia (Fig. 2); scattered populations occur in western North Carolina. In more southern parts of the range, scrub oak is found mainly on eastern slopes of the Appalachians, especially dry slopes of the Alleghenies (Core, 1966). It is particularly common in the anthracite coal region of northeastern Pennsylvania, mainly because of frequent fires and extensive clearcutting (Ineson and Ferree, 1948; Eyre et al., 1954). This plant is characteristic of northeastern pine barrens (Widoff, 1987).

Fruiting is so profuse (more so than in larger oak species) that branches often are covered with clusters of acorns (Pa. Dep. For. Waters, 1951). Sprouts only three years old may bear acorns, although production is greatest when sprouts are 5 to 8 years old. Acorn crops (mast production), which vary from year to year, are adversely

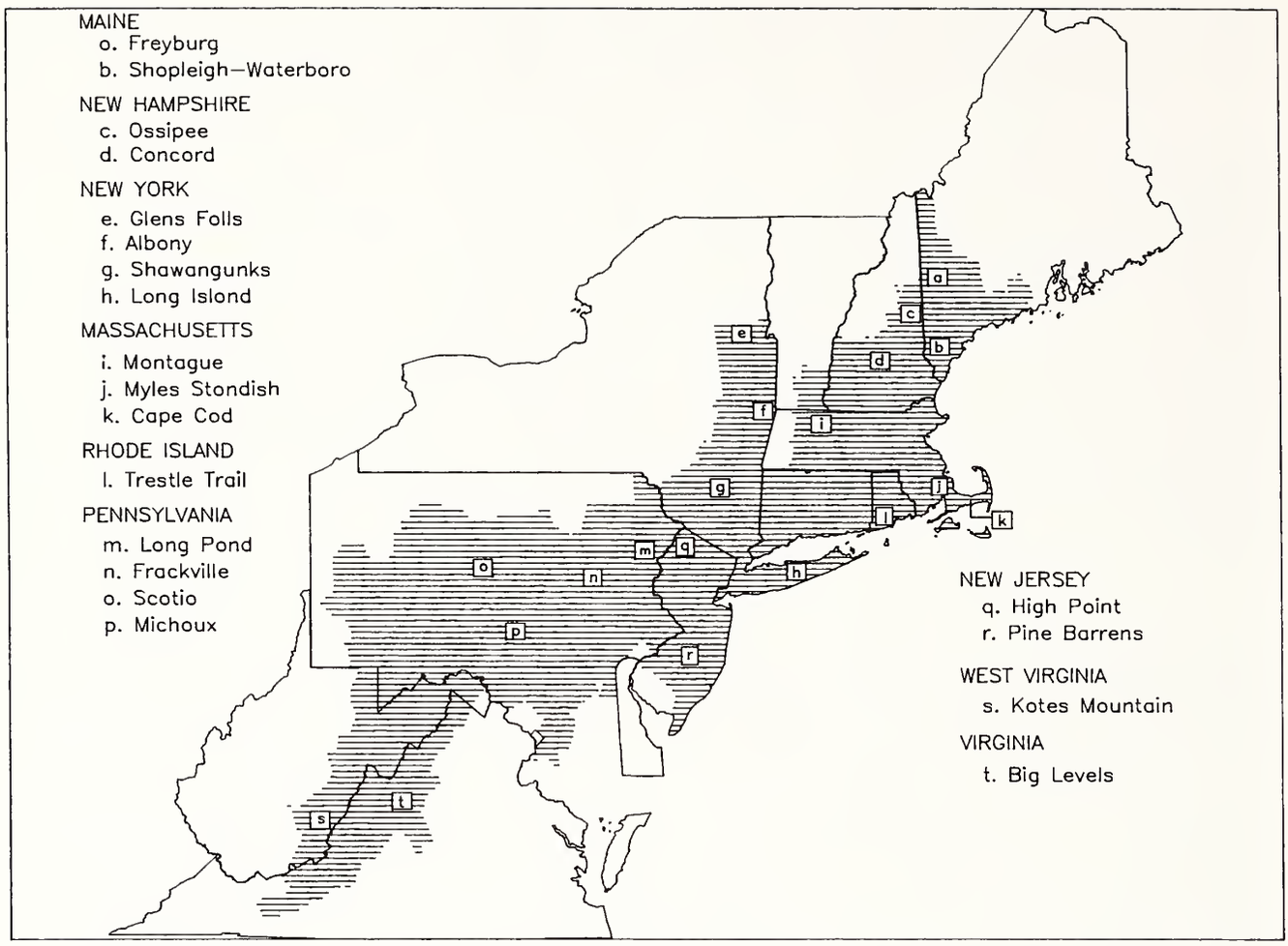

Fig. 2. Distribution of *Quercus ilicifolia* based on Little (1976) (county resolution only, outlier populations omitted) and scrub oak sample sites from Maine to Virginia.

affected by humidity at the time of flowering (Wolgast and Stout, 1977a) and by late spring frosts (Wolgast and Trout, 1979). Genetics also is important in determining acorn yield (Wolgast, 1978).

The importance of scrub oak depends on one's perspective, which is influenced by economic, sociological, and ecological considerations. The tree is too small to be a good timber source, though locally the wood sometimes is used for fuel (Grimm, 1983). And in the early nineteenth century it was used occasionally in New York for fences (Royal Hortic. Soc., 1914). But foresters usually consider scrub oak a troublesome weed because large acreages are rendered unproductive. In areas of frequent fire, it may take 50 years for more valuable tree species to become established. Illick (1924) identified the process of crowding out this noncommercial tree as a major task of modern forestry. With advances in fire protection, forest managers in Pennsylvania could point to substantial reduction in scrub oak forest types: from more than 800,000 ha (2,000,000 acres) in 1920 to only about 69,000 ha (170,000 acres) 30 years later (Pa. Dep. For. Waters, 1951). Attempts at controlling scrub oak have included the use of 2,4, 5-T esters (Worley et al., 1957).

Scrub oak, however, can be considered an important cover plant that protects the forest floor after fires and serves as a nurse crop for valuable trees. It helps prevent erosion and enriches the soil with accumulations of moisture-retaining humus (Pa. Dep. For. Waters, 1951). Rehder (1934) noted its use in covering barren ridges and rocky slopes. *Quercus ilicifolia,* which forms part of a low plant cover along electric

transmission rights-of-way in some areas, is highly resistant to tree seedling invasion and potentially useful in reducing the cost of right-of-way maintenance (Bramble et al., 1990).

Game birds such as turkey, grouse, and quail (Van Dersal, 1938), as well as some nongame birds, feed extensively on the acorns, which represent a highly concentrated food (Wolgast and Stout, 1977b). Bear, deer, and squirrels consume the acorns; deer also browse on the foliage and twigs, particularly in winter when other food is scarce or unavailable (Bramble and Goddard, 1943). Scrub oak is especially important on New Jersey's outer coastal plain, where infertile soils produce little high-quality food for wildlife (Wolgast and Stout, 1977b). In all parts of the range it furnishes cover for a variety of animals throughout the year. Michaux, in fact, thought so highly of the plant as a cover for animals that he (apparently André's son F. A.) recommended it to owners of great estates in Europe (Royal Hortic. Soc., 1914).

Fire exclusion thus can result in deterioration of habitat for wildlife (Hallisey and Wood, 1976). Researchers interested in conserving scrub oak have evaluated the application of fertilizer (and effects of age and stand density) on its reproduction (Wolgast and Stout, 1977b) and investigated the use of prescribed burning to maintain maximum woody browse production for deer (Hallisey and Wood, 1976). One final thought about this plant's value: its ecological importance in "defining and perpetuating the character" (Widoff, 1987) of pine barrens—communities rich in biotic diversity—should be appreciated.

Study sites (Fig. 2). Scrub oak was sampled most intensively in the principal study area: a pine barren in Schuylkill County. Extensive sampling also was conducted at the Long Pond and Scotia barrens (Fig. 2). These Pennsylvania sites are described in some detail, but only brief descriptions of other northeastern pine barrens and similar communities used for inventorying Miridae associated with scrub oak are given.

Frackville (Schuylkill Co.): a moist barren along interstate highway 81 about 8 km southwest of Frackville, elevation about 460 m, apparently fire free for 35–40 years, and the site used by Wheeler and Wilson (1987) to study the little-known issid planthopper *Thionia elliptica* (Germar). They mentioned several plants characteristic of this site; vegetation is similar to that described by Wagner (1943) in scrub oak thickets of Schuylkill Co. and by Donahue (1954) for a scrub oak stand in Luzerne County in Pennsylvania's anthracite region. Mirids at Frackville were sampled along a power line on the east side of the highway.

Lying south of the Poconos, the Frackville site is part of the vast (and probably once continuous) pine barrens region of northeastern Pennsylvania. Forest cover type 43, bear oak, of the American Society of Foresters (Eyre et al., 1954) prevails in the state's anthracite region, mainly in Carbon, Lackawanna, Luzerne, and Monroe counties (Grimm and Whitebread, 1952), and would also include the Frackville study site. Plant communities on these strip-mined areas southwest and west of the Poconos sometimes have been distinguished from barrens within the Pocono Plateau (Oplinger and Halma, 1988).

The northeastern Pennsylvania pine barrens have been little appreciated and seldom cited as communities similar to the New Jersey Pine Barrens, the Albany Pine Bush, or the barrens on Long Island (e.g., Küchler, 1964; Whittaker, 1979). Olsvig et al. (1979) noted the presence of pine barrens in Pennsylvania without mentioning

specific localities. During the 1980s, studies by The Nature Conservancy (Schweitzer and Rawinski, 1986; Widoff, 1987) and the Pennsylvania Natural Diversity Inventory (Wilkinson, 1985) have identified large pine barrens in northeastern Pennsylvania. Although little studied until recently, these communities have been known for many years. Harshberger (1904, 1911) discussed the pine barrens vegetation of northeastern Pennsylvania. He emphasized the close similarity of the "peculiar pine-barren assemblage of species of the mountain floras" of this region, especially in the eastern half of the Pocono Plateau, to the flora of the New Jersey Pine Barrens.

Long Pond (Monroe Co.) (Fig. 1): typical of the Poconos variant (see Description of the natural community), about 2,266 ha on glacial outwash plain just south of Wisconsin terminal moraine, part of a vast semiwilderness that includes boreal wetlands (Wilkinson, 1985). Mirids were sampled mainly in a pitch pine-scrub oak area north of Mud Pond Run and southwest of the village of Long Pond, elev. about 560 m, and in an area southwest near Rt. 115, elev. about 580 m.

Scotia Barrens (Centre Co.): labeled The Great Pine Barrens by an 18th century surveyor (Westerfeld, 1939), about 1,620–2,025 ha of scrub and dwarf chestnut oak, little bluestem and other grasses, scattered pitch pine and aspen, and grassy frost pockets on sandy soil in central part of the Nittany Valley west of State College; wild lupine and northern blazing star (*Liatris borealis* Nutt.) are present; destruction of original oak-chestnut-white pine forest and development of the iron industry with associated railroads, charcoal production, and frequent fires contributed to the vegetation type now present (Westerfeld, 1939, 1959). Mirids were sampled along the main road through State Game Lands No. 176.

Mirids associated with *Quercus ilicifolia* were collected nearly throughout the plant's range (Fig. 2). These additional sites are listed by state, from Maine to Virginia; selected references containing descriptions of the sites and their vegetation are given. In this study, little attention was given to the Long Island and New Jersey pine barrens.

MAINE: pitch pine-scrub oak barrens at Fryeburg, Killick Pond, Shapleigh, and Waterboro in Oxford and York counties (Widoff, 1987).

NEW HAMPSHIRE: pine barrens at Ossipee (Carroll Co.) and remnants of once extensive barrens at Concord, Merrimack Co. (Rawinski, 1987; Cryan, 1985).

MASSACHUSETTS: Cape Cod, Barnstable Co. (Jorgensen, 1978; Olsvig, 1980); Montague Plains, Franklin Co. (Cryan, 1985); and Myles Standish State Forest, Plymouth Co. (Starr, 1926).

RHODE ISLAND: Trestle Trail barrens (Kent Co.) near Connecticut line.

NEW YORK: Glens Falls sand plains, Warren Co. (Cryan, 1985; Reschke, 1990); Albany Pine Bush, Albany Co. (Rittner, 1976, 1980; Olsvig, 1980; Stewart and Rossi, 1981); ridgetop pine barrens at Lake Minnewaska State Park and Mohonk Preserve in Shawangunk Mountains, Ulster Co. (McIntosh, 1959; Kiviat, 1988); and Long Island pine barrens, Suffolk Co. (Cryan, 1980; Olsvig, 1980).

PENNSYLVANIA: ridgetop barrens in Michaux State Forest west of Pine Grove Furnace (Cumberland Co.) and a few small ridgetop barrens not listed in Table 1.

NEW JERSEY: Kittatinny Ridge barrens in High Point State Park, Sussex Co. (Harshberger, 1911; Niering, 1953; Cryan, 1985) and Pine Barrens of southern New Jersey (Harshberger, 1911; Forman, 1979), consisting of a few collections in Burlington and Ocean counties.

WEST VIRGINIA: Kates Mountain shale barren (Keener, 1983) near White Sulphur Springs, Greenbrier Co.

VIRGINIA: Big Levels (Augusta Co.), a quartzite plateau barren at about 1,000 m, similar to northeastern pitch pine-scrub oak barrens but with more tree oaks (T. J. Rawinski, pers. comm.).

Sampling methods. In Pennsylvania, mirids were sampled at Frackville on 5 days from late June to early August 1984, 12 times (weekly or biweekly) from late April to mid-August 1985, 14 times from mid-May to late September 1986, 16 times from late April to late August 1987 (weekly from late April to late July), 4 times from early June to late July 1988, and once (mid-September) in 1990. On each date mirids usually were collected for 30–45 minutes by beating branches of *Q. ilicifolia* over a shallow net and collecting or recording all mirid species and their approximate numbers; notes on plant development also were recorded. Mid- to late instars of taxa that could not be recognized in the field were in many cases reared to maturity in the laboratory. Nymphs were placed in small plastic boxes (about 8 × 2 cm) with twigs (and sometimes staminate flowers or fruits) of the host plant and a water source; presumed predacious species, as well as some phytophages, were provided crushed caterpillars to facilitate rearing. The large number of individuals encountered, however, precluded the rearing of all later instars that could not be field-identified, especially the similar-appearing nymphs of most *Ceratocapsus* and *Phytocoris* spp. Feeding habits of several species were observed in the laboratory.

Pennsylvania barrens at Long Pond and Scotia were sampled less intensively. Collections at Long Pond were made in 1986 (3 days), 1987 (1), and 1990 (2). At Scotia, mirids were collected in 1981 (2 days), 1987 (1), 1988 (1), and 1990 (4). Miridae present on *Q. prinoides,* which is absent from the Frackville and Long Pond barrens, also were noted at Scotia.

Information on Miridae associated with scrub oak in other areas is based on one day's collecting at each site (1–2 hours in August 1990) except for the Albany (New York) Pine Bush (2 days in 1984, 1988) and Maine's Shapleigh-Waterboro barrens (parts of 3 days in August 1990). Voucher specimens have been deposited in the collections of Cornell University, Ithaca, N.Y.; National Museum of Natural History, Washington, D.C.; and Pennsylvania Department of Agriculture, Harrisburg.

RESULTS

Accounts of the Miridae that develop on scrub oak are arranged alphabetically by taxa as in the latest catalog of North American Heteroptera (Henry and Wheeler, 1988). Information provided for the common or characteristic species, as well as some rare or unusual mirids, includes: "Distribution," a summary of the range of widely occurring bugs, or individual records for those known from fewer than 10 states and provinces, and any new state records obtained during this study; and "Biology," a review of selected literature on host plants, seasonal history, and other biological aspects, and any observations obtained from the scrub oak survey. Seldom-collected species for which limited new data can be provided are listed, but only a summary of the known distribution and biology is given, usually in telegraphic form. Table 1 lists all Miridae associated with scrub oak (several *Lygocoris* spp. thought to be vagrants are omitted) and their occurrence in the various communities that were inventoried.

Table 1. Occurrence of Miridae on *Quercus ilicifolia* in pitch pine-scrub oak barrens and similar communities; asterisks denote characteristic scrub oak species.

	ME: Fryeburg	Killick Pond	Shapleigh	Waterboro	MA: Cape Cod	Montague	Myles Standish	NH: Concord	Ossipee	NJ: High Point	Pine Barrens	NY: Albany	Glens Falls	Long Island	Shawangunks	PA: Frackville	Long Pond	Michaux	Scotia	RI: Trestle Tr.	VA: Big Levels	WV: Kates Mtn.
Ceratocapsus																						
*digitulus**	•	•	•	•		•	•	•		•						•	•		•	•	•	
*fasciatus**				•		•							•		•	•					•	•
incisus		•	•	•												•	•					
modestus								•							•							
*pilosulus**			•	•			•			•		•			•	•	•	•				
pumilus										•						•	•					
rubricornis							•				•											
*sericus**			•	•						•						•	•			•		
*vicinus**	•	•	•	•		•	•	•	•	•	•		•	•	•	•	•		•	•	•	•
n. sp.			•																			
Deraeocoris																						
nebulosus				•									•								•	
quercicola			•	•				•				•			•	•	•					
Diaphnocoris																						
provancheri		•		•				•							•	•	•				•	
Eustictus																						
necopinus																			•			
Hyaliodes																						
harti																•	•				•	•
vitripennis[1]										□									•	□		
Lygocoris																						
omnivagus		•	•	•	•	•	•	•				•				•	•		•	•	•	
*semivittatus**				•				•				•				•	•		•			
Noctuocoris																						
fumidus																•						
Phytocoris																						
*antennalis**	•	•	•	•		•	•	•	•	•	•		•		•	•	•		•	•		
canadensis	•	•	•	•		•	•	•		•			•		•	•	•		•	•	•	
erectus									•							•	•					
eximius			•													•			•			

Table 1 (continued)

	ME: Fryeburg	Killick Pond	Shapleigh	Waterboro	MA: Cape Cod	Montague	Myles Standish	NH: Concord	Ossipee	NJ: High Point	Pine Barrens	NY: Albany	Glens Falls	Long Island	Shawangunks	PA: Frackville	Long Pond	Michaux	Scotia	RI: Trestle Tr.	VA: Big Levels	WV: Kates Mtn.
Phytocoris *(cont)*																						
fumatus																•						
husseyi	•															•	•					
lasiomerus												•				•	•		•			
neglectus				•												•						•
olseni *	•						•				•	•				•	•		•			
purvus			•	•			•			•					•	•						
salicis																•	•					
spicatus																•						
n. sp.															•							
Pilophorus																						
furvus				•		•										•						
neoclavatus			•	•			•	•		•					•	•	•	•	•			
setiger												•					•					
Plagiognathus																						
guttulosus																•						
Psallus																						
variabilis					•									•								
Pseudoxenetus																						
regalis *					•							•				•						
Reuteria																						
fuscicornis						•													•		•	•
querci		•		•									•						•		•	
Schaffneria																						
davisi *	•		•	•		•			•		•					•			•			
schaffneri *				•												•						
Taedia																						
hawleyi				•												•			•			
Teleorhinus																						
tephrosicola *											•	•		•		•	•		•			

[1]Open squares represent presence of nymphs or field identification of adults; the species involved may be *H. harti*.

Subfamily Deraeocorinae

Tribe Deraeocorini

Deraeocoris nebulosus (Uhler)

A widely distributed (Henry and Wheeler, 1988) predator of various arthropods on ornamental plants, this species sometimes is common on white oak (Wheeler et al., 1975). It was absent from the Frackville site. Nymphs and adults were present on cut-over scrub oak at Glens Falls, New York, in early August, and occasional adults were taken elsewhere (Table 1).

Deraeocoris quercicola Knight

Distribution. Known from Quebec and Ontario south to Georgia and west to Saskatchewan, Colorado, and New Mexico (Henry and Wheeler, 1988). New records are MAINE: York Co., Shapleigh and Waterboro barrens, Aug. 7–9, 1990, and NEW HAMPSHIRE: Merrimack Co., Concord Barrens, Aug. 6, 1990.

Biology. Knight's (1921) type series was collected on white oak (*Quercus alba*) in New York, and the variety *pallens* was described (in part) from specimens taken on bur oak (*Q. macrocarpa* Michx.) in New York. Bray and Triplehorn (1953) reported an adult from either pin or northern red oak in Delaware. Kelton (1980) listed it as an aphid predator on bur oak in the Prairie Provinces. One of the few mirids previously recorded from scrub oak (Wheeler et al., 1983), it also is known from black oak (*Q. velutina* Lam.) and northern pin oak (*Q. ellipsoidalis* E. J. Hill) (Akingbohungbe et al., 1972) and may also breed on hickory (*Carya* spp.) (Knight, 1941; Wheeler et al., 1983).

Unlike *D. nebulosus,* which produces several generations each season and overwinters as an adult, *D. quercicola* is univoltine and overwinters in the egg stage. In the Frackville Barrens, nymphs (first and second instars) were present in late April, fifth instars occurred as early as the first half of June, and adults appeared by mid- to late June. They were present until early August and were taken in mid-August at Long Pond. This common member of the scrub oak fauna was found in several other northeastern pine barrens (Table 1).

Eustictus necopinus Knight

Known from Quebec and Ontario south to Mississippi and west to Manitoba and Missouri (Larochelle, 1984; Henry and Wheeler, 1988). A new record is Pennsylvania (Scotia Barrens). This poorly known, presumably predacious, mirid has been collected at light and on aspen (*Populus*) (Knight, 1923; Kelton, 1980; Blinn and Yonke, 1985). Its association with *Q. ilicifolia* is based on a fifth instar beaten from the trunk or a main branch of scrub oak at Scotia, July 22, 1990.

Tribe Hyaliodini

Hyaliodes harti Knight

Widely distributed in eastern North America and occurring west to the Prairie Provinces and British Columbia (Henry and Wheeler, 1988), *H. harti* has been reported from bur oak in Wisconsin (Akingbohungbe et al., 1972) and the Prairie

Provinces (Kelton, 1980), and white oak in Missouri (Blinn and Yonke, 1985). It is known to be predacious on mites in apple orchards (Gilliatt, 1935) and on other arthropods (Braimah et al., 1982; Kelton, 1982). Nymphs and adults were common on scrub oak only at Big Levels, Virginia (Table 1).

Hyaliodes vitripennis (Say)

The distribution is similar to that of *H. harti* (Henry and Wheeler, 1988). Predacious on mites (Horsburgh, 1969), aphids, and other arthropods (Braimah et al., 1982; Kelton, 1982), it has been collected on northern red oak and pin oak in Delaware (Bray and Triplehorn, 1953) and on northern red oak and white oak in Missouri (Blinn and Yonke, 1985). A few adults were collected on scrub oak (Table 1), and the occasional nymphs encountered (other than at Big Levels, Virginia) may refer to *H. harti* or *H. vitripennis.*

Subfamily Mirinae

Tribe Mirini

Lygocoris omnivagus (Knight)

Distribution. Known from the Maritime Provinces south to Florida and west from Manitoba to Iowa (Henry and Wheeler, 1988).

Biology. In describing this species, Knight (1917) said that it develops on *Quercus alba, Q. coccinea, Q. prinus,* and *Q. velutina,* and less frequently on other shrubs and trees. He observed that nymphs hatch with the unfolding of host buds and feed on tender foliage. In western New York adults appeared during June 10–22, and most died by early August. Other collection records include bur and northern red oak (Kelton, 1982; Wheeler et al., 1983). *Lygocoris omnivagus* sometimes causes catfacing and gummosis of peaches in eastern North America (Rings, 1958 and references therein).

In the Frackville Barrens, nymphs hatched in early May, and mostly third instars were present during mid-to late May. Adults appeared by early June and were present until mid-August. At Scotia, a female was collected as late as mid-September. This univoltine mirid occurred in many of the northeastern pine barrens surveyed in August 1990 and was collected at Big Levels in Virginia (Table 1).

Lygocoris semivittatus (Knight)

Distribution. Recorded from Ontario and Quebec south to Florida and west from Wisconsin and Minnesota to Missouri and Texas (Henry and Wheeler, 1988). New records are MAINE: York Co., Waterboro Barrens, Aug. 7, 1990, and NEW HAMPSHIRE: Merrimack Co., Concord Barrens, Aug. 6, 1990.

Biology. Knight (1917) described *L. semivittatus* from *Q. alba* in New York. Collections from hickory (*Carya*) and willow (*Salix*) (Kelton, 1971; Blinn and Yonke, 1985) may represent dispersal from oaks.

At Frackville, overwintered eggs hatched before vegetative bud break. First and second instars were present on staminate catkins by late April, second through fourth instars by mid-May, and mostly fifth instars by late May. Development of this univoltine, inflorescence feeder is nearly complete by the time staminate catkins

begin to wither. The first adults were collected on May 30 in 1986 and June 3 in 1987. They were abundant through mid-June and present until early or mid-July. Fifth instars and adults were common in the Albany Pine Bush in early June, and a few females were taken during August in other northeastern pine barrens (Table 1).

Phytocoris antennalis Reuter

Distribution. Known from Quebec and Massachusetts south to Florida and west to Iowa and Oklahoma (Larochelle, 1984; Henry and Wheeler, 1988). New records are MAINE: Oxford Co., Fryeburg Barrens, Aug. 10, 1990; York Co., Killick Pond, Aug. 8; Shapleigh Barrens, Aug. 8; Waterboro Barrens, Aug. 7–9, 1990. NEW HAMPSHIRE: Carroll Co., Ossipee Barrens, Aug. 10; Merrimack Co., Concord Barrens, Aug. 6, 1990. RHODE ISLAND: Kent Co., Trestle Trail, near Greene, Aug. 5, 1990.

Biology. Knight (1941) noted that this species is taken most often at light and that it probably is predacious. It has been collected at black light and in a Malaise trap in Missouri (Blinn and Yonke, 1985), and on *Q. rubra* in Quebec (Larochelle, 1984).

Early instars were not recognized among nymphs of other *Phytocoris* spp. occurring on scrub oak in pine barrens. Collection of a third instar at Frackville on July 1, and fifth instars in the Albany Pine Bush on June 30 suggests that the overwintering eggs hatch by early or mid-June. The earliest record of adults at Frackville was mid-July, but fourth and fifth instars usually were found until the end of July. Mid- to late instars also were present during the latter half of August, suggesting that *P. antennalis* is bivoltine. At the Scotia Barrens, adults were present in mid-September. This characteristic pine barrens species (Table 1) typically was collected only from larger branches of scrub oak.

Phytocoris canadensis Van Duzee

Widely distributed in eastern North America (Henry and Wheeler, 1988). A new record is RHODE ISLAND: Kent Co., Trestle Trail, near Greene, Aug. 5, 1990. Known from numerous deciduous trees and shrubs (Knight, 1941; Kelton, 1982; Wheeler et al., 1983) and predacious on lepidopteran eggs, mites, and aphids (Braimah et al., 1982; Kelton, 1982). Late instars and adults were present at Frackville during July and August; adults were collected from early July to early September. It was common at Long Pond and Scotia barrens in Pennsylvania and High Point State Park in New Jersey and was collected in several other northeastern pine barrens and at Big Levels in Virginia (Table 1).

Phytocoris erectus Van Duzee

Occurring throughout much of eastern North America west to Saskatchewan and, perhaps, Utah (Henry and Wheeler, 1988), although Stonedahl (1988) did not list it from western North America. Collected on various deciduous trees and shrubs (Wheeler et al., 1983; Blinn and Yonke, 1985) and predacious on mites, aphids, caterpillars, and lepidopteran eggs (Kelton, 1980, 1982; Braimah et al., 1982). This species was present during August at Frackville and Long Pond. It was less abundant than *P. canadensis* and was taken in fewer pine barrens than that species (Table 1).

Phytocoris eximius Reuter

A wide-ranging eastern North American species (Henry and Wheeler, 1988) whose habits are little known. It was one of the early-appearing *Phytocoris* at Frackville;

late instars were observed in late May through mid-June and adults during late June to late September. Presence of late instars in mid- to late August suggests that *P. eximius* has two generations.

Phytocoris fumatus Reuter

A poorly known species recorded from Massachusetts to Georgia and west to North Dakota (Henry and Wheeler, 1988). A fifth instar of this species (or near) was collected at Frackville in late June.

Phytocoris husseyi Knight

Recorded only from Minnesota, Nova Scotia, Ohio, Pennsylvania, Quebec, and West Virginia (Henry and Wheeler, 1988). A new record is MAINE: Oxford Co., Fryeburg Barrens (E. Brownfield and Clays Pond area), Aug. 10, 1990. Known as a predator of arthropod eggs, mites, aphids, and caterpillars on fruit trees (Braimah et al., 1982; Kelton, 1982), *P. husseyi* was collected occasionally at Frackville and Long Pond from early August to late September. Late instars were present as late as mid-September.

Phytocoris lasiomerus Reuter

A species of transcontinental distribution in the northern United States and southern Canada (Henry and Wheeler, 1988; Stonedahl, 1988). Pennsylvania (Frackville, Long Pond, and Scotia barrens) is a new state record. *Phytocoris lasiomerus* has been collected on herbaceous plants and on apple and other fruit trees where it feeds on mites, mite eggs, aphids, and other small arthropods (Kelton, 1980, 1982; Braimah et al., 1982). Adults, perhaps having dispersed from other plants, were collected on scrub oak at Frackville and Long Pond throughout July; at Scotia, they were present on *Quercus prinoides.* This species also was present on *Q. ilicifolia* in late June in the Albany Pine Bush.

Phytocoris neglectus Knight

Widely distributed from Nova Scotia, Quebec, and Ontario south to Mississippi and west to the Prairie Provinces, British Columbia, and California (Stonehahl, 1988; Henry and Wheeler, 1988). *Phytocoris neglectus* is found on various deciduous trees, including several oak species in Wisconsin (Akingbohungbe et al., 1972), and on conifers, often occurring on bark (Knight, 1941; Stonedahl, 1988). This apparently bivoltine species (Knight, 1941) is predacious on mites, aphids, psyllids, and psocids (Knight, 1941; Braimah et al., 1982; Kelton, 1982). At Frackville, adults were collected on scrub oak from late June to late September; late instars were particularly common during mid- to late August. Fifth instars and adults also were found at the Kates Mountain shale barren in West Virginia (Table 1).

Phytocoris olseni Knight

Distribution. Known from Colorado, Florida, Mississippi, New Jersey, New Mexico, New York, Texas, and Virginia (Henry and Wheeler, 1988). New records are MAINE: Oxford Co., Fryeburg Barrens (Clays Pond area), Aug. 10, 1990. MASSACHUSETTS: Plymouth Co., Myles Standish State Forest, Aug. 5, 1990. PENN-

SYLVANIA: Monroe Co., Long Pond, and Schuylkill Co., Frackville, numerous records during study.

Biology. The habits of *P. olseni* have not been recorded in the eastern United States. Described from the New Jersey Pine Barrens (holotype, Lakehurst) and several localities in the Long Island barrens (Knight, 1923), it is a characteristic species of northeastern pine barrens. It also is common on shrubby oaks in sand scrub habitats in Florida (Wheeler, unpubl.). Knight (1941) placed *olseni* in a phytophagous group of the genus. Oaks are known as hosts in the West, specifically gambel oak (*Q. gambelii* Nutt.) in Colorado (Stonedahl, 1988). Stonedahl, however, noted that western populations of *P. olseni* possibly represent a distinct species.

At Frackville, overwintered eggs of this univoltine mirid hatched in early to mid-May, third instars usually were present by late May, and fifth instars by early or mid-June. Field observations suggest that early instars feed on staminate catkins. The first adults were seen in mid- to late June and were present until mid- or late July; at Long Pond they were collected as late as mid-August. In the Albany Pine Bush, third and fourth instars were found on 10 June, and fifth instars and adults on 30 June.

Phytocoris purvus Knight

Distribution. Reported from District of Columbia, Iowa, Illinois, Maryland, Missouri, North Carolina, South Carolina, and West Virginia (Blinn and Yonke, 1985; Henry and Wheeler, 1988). New records are MAINE: York Co., Shapleigh and Waterboro barrens, Aug. 7–9, 1990. MASSACHUSETTS: Plymouth Co., Myles Standish State Forest, Aug. 5, 1990. NEW JERSEY: Sussex Co., High Point State Park, July 28, 1990. NEW YORK: Ulster Co., Minnewaska State Park, Aug. 3, 1990. PENNSYLVANIA: Schuylkill Co., Frackville Barrens, several collections during study.

Biology. This species, taken mainly at light, has been collected (1 specimen) on bald cypress [*Taxodium distichum* (L.) L. Rich.] in Illinois (Knight, 1941). A Missouri specimen was taken on a sticky board in "oak hickory canopy" (Blinn and Yonke, 1985).

Uncommon at Frackville, *P. purvus* was collected during July and August; fifth instars were taken throughout July. This species was common on scrub oak at High Point State Park in New Jersey and in the Shapleigh-Waterboro barrens in Maine, where late instars and adults were beaten from lichen-covered branches.

Phytocoris salicis Knight

This widely distributed (Henry and Wheeler, 1988) predator of soft-bodied arthropods and their eggs on apple (Braimah et al., 1982), which also is known from other trees and shrubs (Knight, 1941; Wheeler et al., 1983), was seldom taken on scrub oak (Table 1). A few adults were observed at Frackville in early July; they were seen in larger numbers at Long Pond in early July and were present until mid-August.

Phytocoris spicatus Knight

A wide-ranging (Henry and Wheeler, 1988) but poorly known mirid reported from *Quercus alba* in Missouri (Blinn and Yonke, 1985). Pennsylvania (Frackville Barrens) is a new state record. At Frackville, fifth instars were collected in late May and adults

during late June to early July; bivoltinism is suggested by the presence of late instars in late August. An adult also was collected on the bark of white oak at Frackville.

Phytocoris n. sp.

Two adults of an undescribed species (T. J. Henry, pers. comm.) were collected in New York's Shawangunk Mountains: at Lake Minnewaska State Park and at Mohonk Preserve.

Taedia hawleyi (Knight)

This mirine, previously recorded from the District of Columbia, Indiana, Massachusetts, Maine, Maryland, New York, and Ohio (Henry and Wheeler, 1988), has been studied as a pest of hops (*Humulus lupulus* L.) in New York (Hawley, 1917). Late instars and a few adults were collected from withering staminate inflorescences of scrub oak at Scotia Barrens (Pennsylvania is a new state record) in mid-June 1981. This apparent general feeder also was found on inflorescences of shrubs such as *Cornus racemosa* Lam. and *Elaeagnus* sp. at Scotia. At Frackville, *T. hawleyi* developed mainly on *Aronia arbutifolia* (L.) Ell. and only occasional nymphs were seen on scrub oak. An adult was collected from scrub oak in Maine's Waterboro Barrens in August.

Subfamily Orthotylinae

Tribe Ceratocapsini

Ceratocapsus digitulus Knight

Distribution. Known from Quebec and Ontario south to North Carolina and west to Manitoba and Missouri (Henry and Wheeler, 1988). New records are MAINE: Oxford Co., Fryeburg Barrens (E. Brownfield), Aug. 10, 1990; York Co., Killick Pond, Shapleigh, and Waterboro barrens, Aug. 7–9, 1990. NEW HAMPSHIRE: Merrimack Co., Concord Barrens, Aug. 6, 1990. NEW JERSEY: Sussex Co., High Point State Park, July 28, 1990. RHODE ISLAND: Kent Co., Trestle Trail near Greene, Aug. 5, 1990.

Biology. Few host records are available for this poorly known plant bug. It has been taken on sandbar willow (*Salix exigua* Nutt.) in Manitoba (Kelton, 1980) and on fruit trees in Ontario and Quebec (Kelton, 1982); nymphs and adults feed on mites and aphids (Braimah et al., 1982).

Early instars were not recognized among nymphs of *Ceratocapsus* spp. occurring at Frackville. Fourth instars were collected in late June, and the first adults were taken in early July. They were sometimes abundant in mid- to late July and, in most years, were present until late August or early September. This univoltine bug was collected in most northeastern pine barrens and at Big Levels, Virginia (Table 1).

Ceratocapsus fasciatus (Uhler)

Distribution. Widespread in eastern North America from southern Canada to Georgia and known from California and Colorado (Henry and Wheeler, 1988). A new record is MAINE: York Co., Waterboro Barrens, Aug. 7, 1990.

Biology. This species occurs most often on hickory (*Carya* spp.) (Knight, 1923,

1941; pers. obs.) but has been recorded from *Quercus macrocarpa* in Wisconsin (Akingbohungbe et al., 1972); Bray and Triplehorn (1953) took one adult during their survey of *Q. palustris* and *Q. rubra* in Delaware.

Only one adult was collected on scrub oak (late July) at the Frackville site, where the similar-appearing *C. pilosulus* was common. *Ceratocapsus fasciatus,* however, appeared to be characteristic of certain northern pine barrens (Table 1). In early August, late instars and adults were found in New York's Shawangunk Mountains, where this species coexisted on scrub oak with *C. pilosulus.* In Massachusetts, only *C. fasciatus* was present in the inland Montague sand plains, whereas only *C. pilosulus* occurred in Myles Standish State Forest near the coast.

Ceratocapsus incisus Knight

Known from Ontario south to West Virginia and west to Wisconsin and Missouri (Henry and Wheeler, 1988). A new record is MAINE: York Co., Killick Pond, Shapleigh, and Waterboro barrens, Aug. 7–9, 1990. *Ceratocapsus incisus* has been recorded from various fruit trees in Ontario, where it preys on aphids (Kelton, 1982), and from several hardwood trees (Knight, 1941; Wheeler et al., 1983, Blinn and Yonke, 1985). Adults were collected occasionally at Frackville during July and at Long Pond in mid-August; small numbers were present in the Maine barrens listed above.

Ceratocapsus modestus (Uhler)

Widespread in eastern North America from southern Canada to Florida, ranging west to Saskatchewan, Colorado, and New Mexico (Henry and Wheeler, 1988). A new record is NEW HAMPSHIRE: Merrimack Co., Concord Barrens, Aug. 6, 1990. This species occurs on grape (*Vitis* spp.) and various trees, including pin and northern red oak in Delaware (Bray and Triplehorn, 1953), bur oak in Wisconsin (Akingbohungbe et al., 1972) and the Prairie Provinces (Kelton, 1980), five *Quercus* spp. in Pennsylvania (Wheeler and Henry, 1978), and white oak in West Virginia. It is predacious on mites, aphids, whiteflies, and phylloxeran eggs (Wheeler and Henry, 1978; Braimah et al., 1982; Kelton, 1982). This univoltine predator was not taken in Pennsylvania barrens, but a fifth instar was beaten from scrub oak at Minnewaska State Park in New York; two adults were collected in the Concord (N.H.) Barrens.

Ceratocapsus pilosulus Knight

Distribution. Known from Quebec and Ontario south to New York and west to Manitoba (Larochelle, 1984; Henry and Wheeler, 1988). New records are MAINE: York Co., Shapleigh and Waterboro barrens, Aug. 7-9, 1990, and PENNSYLVANIA (Frackville and Long Pond).

Biology. Reported from several tree species, including bur oak in Illinois (Knight, 1941), Wisconsin (Akingbohungbe et al., 1972), and the Prairie Provinces (Kelton, 1980), and known to prey on aphids (Kelton, 1982). At Frackville, fifth instars were collected from mid- to late June, the adults appearing by early July (adults were present in late June in the Albany Pine Bush). Collection of a fifth instar in late August could have represented a second generation or the late hatching of overwintered eggs. This species appeared to be more abundant at Long Pond, where large numbers of adults were observed from early July to mid-August. The latest collection

(Sept. 29) was made at a scrub oak site near Frackville. *Ceratocapsus pilosulus* was found consistently on heavily fruiting trees, a habit of unknown significance but one also reported for this mirid in Quebec (Larochelle, 1984).

Ceratocapsus pumilus (Uhler)

Widespread in eastern North America from southern Canada to Florida and west to Colorado and Kansas (Henry and Wheeler, 1988), found on grape (*Vitis*) and various shrubs and trees (Knight, 1941; Kelton, 1982; Wheeler et al., 1983; Blinn and Yonke, 1985), and predacious on mites and aphids (Braimah et al., 1982; Kelton, 1982). Adults were taken occasionally from late July to mid-August at Frackville and Long Pond; this species also was present at High Point State Park, New Jersey.

Ceratocapsus rubricornis Knight

Known from District of Columbia, Delaware, Illinois, Mississippi, Missouri, Pennsylvania, and West Virginia (Blinn and Yonke, 1985; Henry and Wheeler, 1988). New records are MASSACHUSETTS: Plymouth Co., Myles Standish State Forest, Aug. 5, 1990, and NEW JERSEY: Ocean Co., Rt. 70 nr. Whiting, June 15, 1980. This poorly known bug has been reported mainly from *Quercus* spp. (Henry, 1979), including pin oak and northern red oak in Delaware (Bray and Triplehorn, 1953) and pin oak and willow oak (*Q. phellos* L.) in West Virginia (Wheeler et al., 1983); records from other trees (*Castanea, Tilia*) possibly represent sitting records. Scrub oak collections are limited to the adult noted above from Massachusetts and a third or fourth instar from the New Jersey Pine Barrens.

Ceratocapsus sericus Knight

Distribution. Reported from Illinois, Michigan, New Jersey, New York, Pennsylvania, and Wisconsin (Henry and Wheeler, 1988). New records are MAINE: York Co., Shapleigh and Waterboro barrens, Aug. 7–9, 1990, and RHODE ISLAND: Kent Co., Trestle Trail, near Greene, Aug. 5, 1990.

Biology. Henry (1979) reported northern red oak in Pennsylvania as the first host record for this seldom-collected plant bug. At Frackville, overwintered eggs of this univoltine species hatched in early June, third to fifth instars were found during mid- to late June, and adults began to appear by the first week in July. Adults were present until mid-August, and females have been collected as late as 8 September. This characteristic scrub oak mirid was collected in several other northeastern pine barrens (Table 1).

Ceratocapsus vicinus Knight

Distribution. Illinois, Missouri, New Jersey, New York, Pennsylvania, and West Virginia (Henry and Wheeler, 1988) are the only published records. New records are MAINE: Oxford Co., Fryeburg Barrens, Aug. 10, 1990; York Co., Killick Pond, Shapleigh, and Waterboro barrens, Aug. 7–9, 1990. MASSACHUSETTS: Franklin Co., Montague Plains, Aug. 4, 1990; Plymouth Co., Myles Standish State Forest, Aug. 4, 1990. NEW HAMPSHIRE: Carroll Co., Ossipee Barrens, Aug. 10, 1990; Merrimack Co., Concord Barrens, Aug. 6, 1990. RHODE ISLAND: Kent Co., Trestle Trail nr. Greene, Aug. 5, 1990. VIRGINIA: Augusta Co., Big Levels Barren, Aug. 26, 1990.

Biology. Knight (1923) described *C. vicinus* from Staten Island, New York (holotype), and from well-known pine barrens areas on Long Island (e.g., Yaphank) and in New Jersey (e.g., Lakehurst). Hosts were unknown until Henry (1979) reported it from willow oak in Pennsylvania. At Frackville, first through fourth instars were not distinguished from nymphs of other *Ceratocapsus* spp. Fifth instars were found from early July to early August; adults were present by mid-July, often common from late July to mid-August, and usually could be collected through August. The latest record (a female) was 29 September. Considered a characteristic species of the scrub oak fauna, *C. vicinus* was taken in numerous pine barrens (Table 1) and was the most abundant mirid present in early August at the Concord, Montague, Myles Standish, and Trestle Trail barrens in New England.

Ceratocapsus n. sp.

In Maine, an undescribed species (one male) of the *lutescens* group (T. J. Henry, pers. comm.) was collected in the Shapleigh Barrens. Some species of this group develop on oaks and other deciduous trees, whereas others are pine specialists (Henry, 1979). Studies are needed to determine whether the Maine species is associated with *Quercus.*

Schaffneria davisi (Knight)

Described from the New Jersey Pine Barrens (Lakehurst and Manumuskin) (Knight, 1923), this interesting plant bug is known elsewhere only from Manitoba (Kelton, 1980). New records are MASSACHUSETTS: Franklin Co., Montague Plains, Aug. 4, 1990. MAINE: Oxford Co., Fryeburg Barrens (Clays Pond area), Aug. 10; York Co., Shapleigh and Waterboro barrens, Aug. 7–9, 1990. NEW HAMPSHIRE: Carroll Co., Ossipee Barrens, Aug. 10, 1990. PENNSYLVANIA: Centre Co., Scotia Barrens, July 19, 1990; Schuylkill Co., Frackville Barrens, 1986–90.

Biology. Kelton's (1980) record from bur oak in Manitoba remains the only information on this bug's habits. *Schaffneria davisi* was not found on scrub oak at Frackville until late July 1986. This antlike or myrmecomorphic bug was detected only when collecting on trees colonized by a glossy brownish-black aphid (*Lachnus allegheniensis* McCook) that was tended by a glossy black ant [*Dolichoderus taschenbergi* Mayr)] (Fig. 3). When branches with aphid-infested twigs or leaves were tapped over a net, one or two of the numerous "ants" appeared slightly different; they proved to be *S. davisi.* The mirid also was collected from ant-attended colonies of a tiny yellow aphid [*Myzocallis bella* (Walsh)] on the same or nearby trees. Colonies of both aphids sometimes were found on the same terminal or even same leaf.

It is apparent now why *S. davisi* is so little known, rare in collections, and had not been encountered previously at the main study site. In pine barrens it is always taken with the ant *D. taschenbergi,* which it closely resembles; both are fuscous or nearly so, mostly glabrous, glossy, and of similar size. Distinguishing mirid from ant is difficult when the ratio in the net is 1:50 or 1:100. In addition, colonies of the myrmecophilic *L. allegheniensis,* and apparently also *M. bella,* occur only near nests of *D. taschenbergi* and thus are patchily distributed in a barren. Bradley and Hinks (1968) observed that nests of this ant were absent from habitat areas seemingly identical to those with nests. The scattered nests of *D. taschenbergi* remain in the same

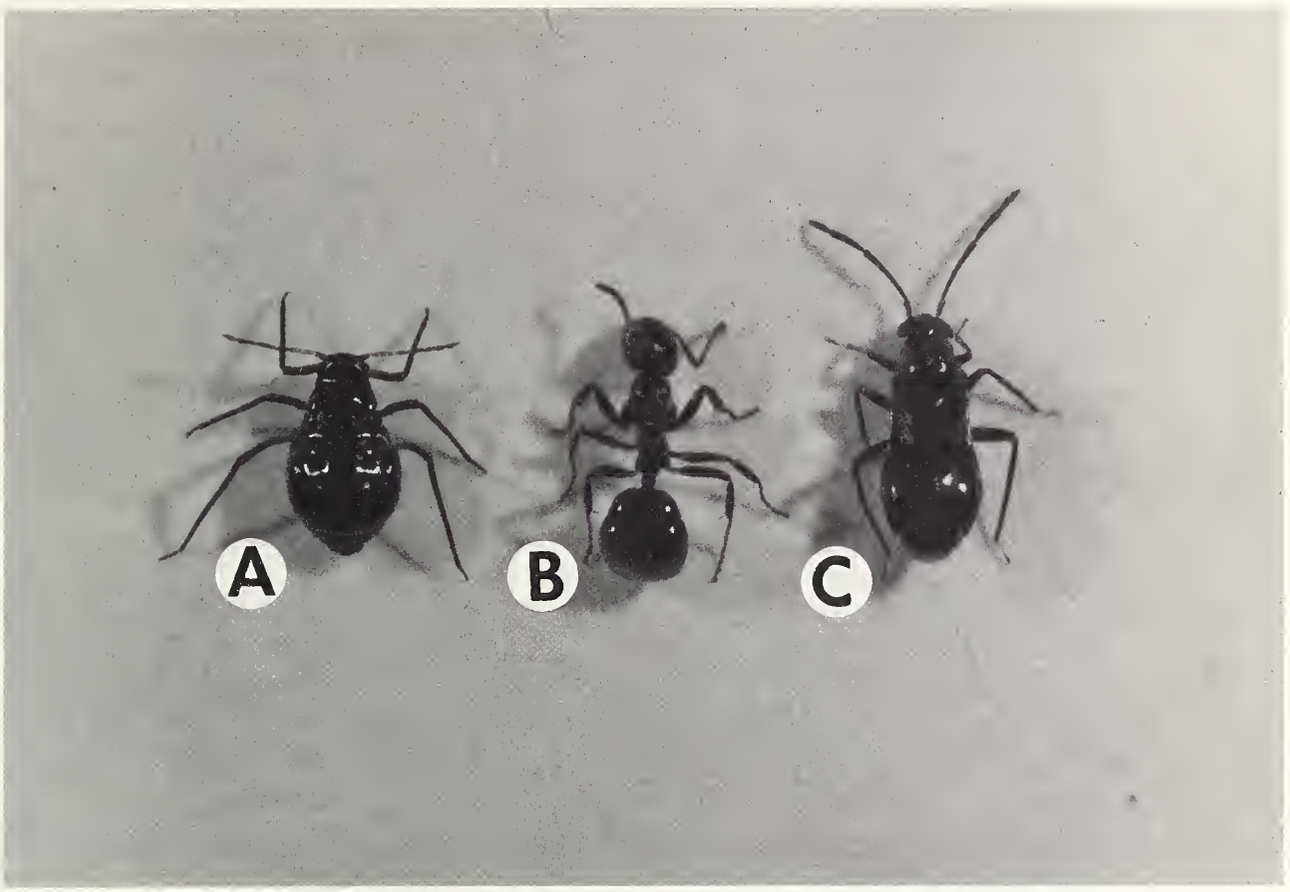

Fig. 3. Members of a presumed Batesian mimicry system on scrub oak. A. The aphid *Lachnus allegheniensis*. B. The ant *Dolichoderus taschenbergi*. C. The myrmecomorphic plant bug *Schaffneria davisi*.

positions year after year (Bradley, 1972), and at Frackville colonies of the aphids *L. allegheniensis* and *M. bella* remained on the same trees in succeeding seasons, a habit noted in other aphid species tended by this ant (Bradley and Hinks, 1968).

The restriction of *S. davisi* to trees harboring aphids and attendant ants—at Frackville and Scotia in Pennsylvania as well as in New England barrens—is hardly coincidental, but the adaptive significance of this relationship within the arthropod community on scrub oak remains untested. Without field or laboratory evidence for a selective advantage of ant resemblance, this apparent ant mimicry is termed myrmecomorphy. It is hypothesized that *S. davisi* derives protection from visual predators that have learned to avoid noxious ants and represents a classic Batesian mimic. Protection of certain ant-resembling heteropterans [*Hyalymenus* spp. (Alydididae) in Brazil] has been experimentally demonstrated (Oliveira, 1985). In Oregon, McIver (1989) has shown that the palatable antlike mirid *Coquillettia insignis* Uhler gains protection from visually oriented predators such as spiders and assassin bugs (Reduviidae) occurring on the bug's host plant.

In addition to its presumed defensive mimicry, seasonal history and habits of *S. davisi* require more study. At Frackville, this plant bug may be bivoltine. Nymphs, mostly third but a few fourth instars, were observed in early June, fifth instars by late June, and the first adults in early July. Adults usually were common during July. Third to fifth instars of a probable second generation were present in mid- to late August, and fifth instars and adults were found through September.

Fig. 4. *Schaffneria davisi* preying on the aphid *Myzocallis bella.*

In the field, nymphs and adults were observed on trunks and main branches near lines of streaming worker ants and on leaves near ant-attended aphids. In the laboratory, *S. davisi* fed on crushed caterpillars. When placed with unattended *Myzocallis* colonies, they aggressively attacked apterous aphids (Fig. 4), usually feeding on several prey in succession. They sometimes deflated their prey, but at times fed briefly, then left a struggling aphid to attack another individual in the colony. When confined with ants and aphids, the mirids were unable to invade the colonies. Ants repelled but did not pursue the bugs, which usually retreated to the underside of a nearby leaf. In nature, the bugs may feed mainly on aphids that stray from colonies, perhaps supplementing this diet with aphid honeydew and scavenging. Ants appear to prevent *S. davisi* from decimating the aphid population. Further study of this possible co-

evolved aphid-ant-plant bug system, including the mirid's use of trail substances or other ant pheromones, is needed.

Schaffneria schaffneri Knight

Distribution. Knight (1966) described this mirid from College Station, Texas, and it has been reported subsequently only from Alberta and Saskatchewan (Kelton, 1980). I note that Kelton's map shows only a record for Saskatchewan and that Henry and Wheeler (1988) inadvertently listed Alberta as Arizona. New records are MAINE: York Co., Waterboro Barrens, Aug. 7, 1990, and PENNSYLVANIA: Schuylkill Co., Frackville Barrens (see discussion below).

Biology. The type specimen and associated material were collected on the ground under red cedar (*Juniperus virginiana* L.) trees; adults and nymphs were observed running and hiding among litter (Knight, 1966). On the basis of observations by M. H. Sweet, Knight said that the bugs may feed on fallen cedar fruits and may be associated with ants. In the Prairie Provinces, Kelton (1980) reported *S. schaffneri* from the grass *Beckmannia syzigachne* (Steud.) Fern.

Schaffneria schaffneri was not as abundant as *S. davisi* at Frackville. In collections of *Schaffneria* adults in 1986, *S. schaffneri* represented 1 of 7 on July 22, 2 of 8 the next day, 3 of 11 on Aug. 1, and 4 of 26 on Aug. 15. Both mirids were collected from the same ant-attended colonies of the aphids *Lachnus allegheniensis* and *Myzocallis bella.* Nymphs presumably were present but were not distinguished from those of *S. davisi.* In Maine's Waterboro Barrens, only one adult was collected, although *S. davisi* was common on scrub oak in certain areas. The comments made about the probable defensive adaptations of *S. davisi* also apply to *S. schaffneri.*

Tribe Orthotylini

Diaphnocoris provancheri (Burque)

Widespread in eastern North America from southern Canada to Georgia, occurring in the Pacific Northwest, California, Colorado, and the Prairie Provinces (Henry and Wheeler, 1988). It is predacious on mites, mite eggs, aphids, leafhoppers, psyllids, and lepidopteran larvae and eggs (Stear, 1925; Braimah et al., 1982; Kelton, 1982) and is found on numerous shrubs and trees, including *Quercus alba, Q. macrocarpa, Q. palustris, Q. prinus,* and *Q. rubra* (Knight, 1941; Kelton, 1980; Wheeler et al., 1983). Adults only were taken in small numbers at Frackville and several other pine barrens (Table 1).

Noctuocoris fumidus (Van Duzee)

Widely distributed across the northern United States and southern Canada, ranging south to Colorado, Utah, and Oklahoma (Schwartz and Stonedahl, 1986). It has been taken at light and on *Carya* and *Quercus* in Canada (Schwartz and Stonedahl, 1986), specifically *Q. macrocarpa* in the Prairie Provinces (Kelton, 1980). Larochelle (1984) collected *N. fumidus* on profusely fruiting oak in Quebec. During the study of scrub oak Miridae, this apparently predacious bug was collected only at Frackville. Small numbers of adults (1–4) were beaten from large branches on each of three sample dates in July 1986.

Pseudoxenetus regalis (Uhler)

Distribution. Reported from Ontario and Quebec south to Florida and west to the Great Lakes region and Oklahoma (Larochelle, 1984; Henry and Wheeler, 1988).

Biology. Blinn's (1988) study of *P. regalis* on white oak in Missouri showed that overwintered eggs hatched shortly after vegetative bud break (early to mid-April), nymphs developed on staminate catkins and tender foliage, adults appeared by early May, and were present only for 3–4 weeks. He noted that this univoltine oak specialist has been collected from other *Quercus* spp., which include members of the red and white oak groups.

At Frackville, egg hatch occurred while staminate catkins were developing but before vegetative bud break on *Q. ilicifolia.* First instars usually were collected during the first week of May, fifth instars about May 20, and the first adults by late May or early June. The somewhat myrmecomorphic nymphs develop rapidly on staminate catkins and perhaps also on expanding foliage. Unlike many of the mirids on scrub oak, egg hatch of *P. regalis* apparently takes place over a short period, and nymphal development is well synchronized; only two instars were present in any sample. Adults were most numerous (sometimes 30–40/sample) in early to mid-June and usually were found until late June or early July. The latest record was July 12.

Pseudoxenetus regalis was one of the most abundant mirids at Frackville and may be characteristic of most pine barrens. Because scrub oak in many other areas was sampled well after the disappearance of this early-season species, few records of *P. regalis* were obtained (Table 1).

Reuteria fuscicornis Knight

Recorded from Ontario south to Maryland and District of Columbia and west to Minnesota, and Iowa (Henry and Wheeler, 1988). This orthotyline has been reported mainly from American hornbeam (*Carpinus carolinianum* Walt.) and hop hornbeam (*Ostrya virginiana* L.), but also from chestnut (*Castanea*) and dogwood (*Cornus*) (Knight, 1941; Henry, 1976). In Pennsylvania, *R. fuscicornis* was found only at the Scotia Barrens where small numbers of adults were taken from late August to mid-September. Because nymphs were not encountered, this species may be incidental on scrub oak, adults having dispersed from their breeding hosts. The collection of large numbers of *R. fuscicornis* from the Big Levels Barrens in Virginia and teneral adults in the Montague (Massachusetts) Plains suggests that *Q. ilicifolia* sometimes serves as a host.

Reuteria querci Knight

Known from New York to Georgia and west to Manitoba and Missouri (Henry and Wheeler, 1988). A new record is MAINE: York Co., Killick Pond and Waterboro barrens, Aug. 7–8, 1990. Bur oak has been recorded as its host in Illinois (Knight, 1941), Wisconsin (Akingbohungbe et al., 1972), and Manitoba (Kelton, 1980); post oak (*Q. stellata* Wangenh.) is a host plant in North Carolina (Henry, 1976). *Reuteria querci* was found at Scotia Barrens, but was absent from the Frackville and Long Pond barrens in Pennsylvania. Fourth and fifth instars were collected in mid-July, fifth instars and teneral adults in late July. Adults were taken in the Glens Falls (New York) sand plains and, as noted above, in Maine barrens; the largest number of adults was collected at the Big Levels, Virginia, site.

Subfamily Phylinae

Tribe Hallodapini

Teleorhinus tephrosicola Knight

Distribution. Described from pine barrens on Long Island, New York (Yaphank), and the New Jersey Pine Barrens (Lakehust) (Knight, 1923), it has been reported since from Missouri and Pennsylvania (Henry and Wheeler, 1988).

Biology. The specific name refers to its apparent host, goat's-rue (*Tephrosia virginiana* L.), a characteristic plant of the Long Island barrens (Cryan, 1980). Late-season collection of the holotype and allotype on flowers of this plant at Yaphank may, however, represent merely a sitting record or dispersal to goat's-rue to feed on nectar or pollen. No other biological information is available on this seldom-collected mirid.

Teleorhinus tephrosicola, although never numerous in samples, was a characteristic scrub oak species at Frackville. First instars were collected as early as May 12, third instars were present by May 20, fifth instars by early June, and the first adults by mid- to late June. Adults were never as common as nymphs on *Q. ilicifolia.* In some years they were observed until late July, but usually they disappeared earlier (a dead adult was beaten from scrub oak on July 15).

The myrmecomorphic nymphs somewhat resemble those of *Pseudoxenetus regalis* but are darker and lack a white or yellowish scutellar spot. Nymphs of *T. tephrosicola* also move much more rapidly over host plants than *P. regalis* nymphs. In the laboratory, nymphs fed on staminate catkins and probed lateral veins and midribs of scrub oak leaves; they fed readily on crushed caterpillars.

In the Albany Pine Bush late instars were observed in early June and an adult in late June. This univoltine mirid also occurred on scrub oak in the Long Pond and Scotia barrens. Early-season collecting is needed to determine whether it is present in New England barrens.

Tribe Phylini

Plagiognathus guttulosus (Reuter)

Distribution. Recorded from Colorado, Florida, Georgia, Illinois, Mississippi, Missouri, and Texas (also known from Mexico) (Henry and Wheeler, 1988). A new record is Pennsylvania (Frackville Barrens).

Biology. Information on host plants is limited to Knight's (1941) record from *Quercus* sp. in Illinois. *Plagiognathus guttulosus* has been collected at light in Illinois and Missouri (Knight, 1941; Blinn and Yonke, 1985).

This early-season inflorescence feeder was encountered only at Frackville. Overwintered eggs hatched in late April when staminate catkins were not fully developed and before leaves unfolded. Third instars were present by mid-May, fifth instars in late May (as early as the 20th), and the first adults in late May or the first week of June. Development takes place rapidly on staminate flowers, and the brownish late instars are well camouflaged on withering catkins. As in *Pseudoxenetus regalis,* populations consist of only one or two instars at any time; all fifth instars become adults within a several-day period. Adults generally were abundant (15–20+ individuals in samples) during mid-June, but their numbers declined quickly. In late June a female

had dispersed to an inflorescence of fly poison, apparently to feed on nectar or pollen. The latest record of this univoltine bug was July 8.

Psallus variabilis (Fallén)

An immigrant species detected in North America on Long Island, New York, in 1979 (Hoebeke, 1980) and later reported from additional localities on Long Island (Wheeler and Hoebeke, 1982). A new record is MASSACHUSETTS: Barnstable Co., North Falmouth, May 28, 1988. On Long Island, nymphs developed on *Q. ilicifolia,* where they appeared to feed mainly on staminate catkins; adults of this adventive mirid have been collected on *Q. coccinea* (Wheeler and Hoebeke, 1982). This early-season, univoltine bug also was collected from scrub oak on Cape Cod, Massachusetts (as noted above), where nymphs were beaten from catkins.

Tribe Pilophorini

Pilophorus furvus Knight

Distribution. Described by Knight (1923) from the New Jersey Pine Barrens (Lakehurst), it is now known to occur in Alabama, Maryland, Mississippi, North Carolina, and Pennsylvania (Schuh and Schwartz, 1988). Schuh and Schwartz did not list the Manitoba record of Bradley and Hinks (1968). Kelton (1980) also did not include *P. furvus* in his Miridae of the Prairie Provinces (he had, however, identified *P. furvus* from Manitoba for Bradley and Hinks), and Henry and Wheeler (1988) said that the Canadian record needed verification. New records are MAINE: York Co., Waterboro Barrens, Aug. 7, 1990, and MASSACHUSETTS: Franklin Co., Montague Plains, Aug. 4, 1990.

Biology. Schuh and Schwartz (1988), on the basis of information I provided for Pennsylvania populations, reported *P. furvus* from Virginia pine (*Pinus virginiana* Mill.) and from *Q. ilicifolia* (Frackville Barrens). If the Manitoba record of Bradley and Hinks (1968) is valid (I am inclined to accept it based on habitat type, their biological data, and the information I have obtained on this species in northeastern pine barrens), then *P. furvus* also lives on jack pine (*P. banksiana* Lam.), on which it attacks *Cinara* aphids that stray from ant-attended colonies.

Like *Schaffneria davisi* and *S. schaffneri, P. furvus* was collected on scrub oak when aphids tended by the ant *Dolichoderus taschenbergi* were located. At Frackville, it was found only in 1987. On July 8, a fourth and a fifth instar were taken with three adults from colonies of the aphid *Lachnus allegheniensis*; a week later, two adults were collected. *Schaffneria davisi* also was present in the same aphid colonies on both dates.

Schuh and Schwartz (1988) pointed out that members of the *P. furvus* species group typically develop on pines and that further field observations would determine whether the Frackville collections from scrub oak represented a breeding record. This species develops on Virginia pine in Pennsylvania and elsewhere in the eastern United States (personal observations), as well as on jack pine in Manitoba (Bradley and Hinks, 1968). Collection of a few adults from *Dolichoderus*-attended aphid colonies on scrub oak in two New England barrens suggests that *P. furvus* belongs to the complex of myrmecomorphic Miridae associated with the aphid-ant-scrub oak sys-

tem. Perhaps the presence of ants and aphids is more important than plant species in determining host relationships of this myrmecomorph.

Pilophorus neoclavatus Schuh & Schwartz

Distribution. Recently described (holotype from Frackville Barrens) for a species long misidentified as *P. clavatus,* an Old World mirid established in parts of North America (Schuh and Schwartz, 1988). This species also has been confused with other North American *Pilophorus* such as *P. brunneus* Poppius. For example, the West Virginia record of *P. brunneus* (Wheeler et al., 1983) should be referred to *P. neoclavatus* (see Schuh and Schwartz, 1988). In describing this species, Schuh and Schwartz recorded it from Ontario and Quebec south to North Carolina and west through the midwest and Great Lakes region to the Prairie Provinces.

Biology. Pilophorus neoclavatus has been collected from shrubs and trees, including *Q. ilicifolia* and *Q. palustris* in Pennsylvania and *Q. stellata* in North Carolina (Schuh and Schwartz, 1988). At Frackville, it was collected consistently but in small numbers (generally <5 individuals per sample date) and usually relatively late in the season. The first nymphs observed were third instars in late June. Adults were present from late June until mid-August. Collection of late instars in early August may indicate that two generations are produced. *Pilophorus clavatus* was collected in several northeastern pine barrens (Table 1).

Pilophorus setiger Knight

Schuh and Schwartz (1988) examined specimens from Illinois, Indiana, Massachusetts, Minnesota, Nebraska, New Jersey, New York, North Dakota, and Pennsylvania (Long Pond Barrens); they were unable to confirm Kelton's (1980) record from Manitoba. It also is known from South Dakota (Knight, 1973). The only host information, except for *Q. ilicifolia* at Long Pond, is a record from *Corylus* sp. (Schuh and Schwartz, 1988). *Pilophorus setiger,* absent from the Frackville Barrens, was common on scrub oak at Long Pond during mid-August (adults and late instars). This species also was collected in the Albany Pine Bush (Table 1).

DISCUSSION

Forty-four species of plant bugs were collected on *Quercus ililcifolia* in pine barrens and in similar natural communities from Maine to Virginia. Species richness varied greatly among the sites inventoried. As might have been expected from island biogeography theory (MacArthur and Wilson, 1967), the number of mirids found on scrub oak was consistently greater in larger barrens such as Frackville (33 species) and Long Pond (21) in Pennsylvania and in Maine's Waterboro Barrens (21). With additional collecting, the Albany Pine Bush, Long Island and New Jersey pine barrens, and Montague Plains and Myles Standish State Forest in Massachusetts almost certainly can be added to this list. In Maine pine barrens, species richness near the northern limit of scrub oak's range was nearly as great as that of any of the communities that were inventoried. The number of species associated with scrub oak at Waterboro might approach that of other barrens if early-season collections are made.

Species richness in remnant pine barrens such as Concord, New Hampshire, and

in most small ridgetop barrens did not approach that of the larger, more floristically diverse pine barrens communities. More intensive collecting in the large ridgetop barrens in the northern Shawangunk Mountains of New York and in the southern Appalachians, especially Big Levels plateau in Virginia, may reveal a mirid fauna nearly as diverse as that of some large northeastern pitch pine-scrub oak barrens.

Scrub oak appears to have a richer plant bug fauna than some larger oak species in eastern North America, although experimental data are needed to confirm this supposition. *Quercus ilicifolia,* as a shrub oak, might have been predicted on the basis of plant structural diversity to harbor a less diverse plant bug fauna than canopy oaks. When plants of similar-sized geographic ranges are compared, insect species richness typically is greater with architecturally more complex plants (Strong et al., 1984). Cornell and Washburn (1979), however, found that the gall wasp fauna of certain shrubby oaks was about as rich as that of some tree oaks.

Diversity of the scrub oak fauna possibly can be attributed to a preference of many plant bugs for open areas. Shrub-and tree-associated species are found more often on isolated trees or on hosts in hedgerows (Knight, 1941; pers. obs.). That the shade-intolerant *Q. ilicifolia* is typical of communities having a sparse, interrupted canopy and often occurs in extensive patches or colonies may therefore contribute to its faunal richness. Scrub oak's tangled, interlacing branches also may provide ideal shelter that allows a diverse predator fauna to develop, particularly bark-inhabiting *Ceratocapsus* and *Phytocoris* spp.

The fauna consists of phytophagous and predacious species and, undoubtedly, mixed feeders that use plant and animal matter. Degree of intimacy with the plant ranges from a few species taken only as adults and which possibly are vagrants that have dispersed from their hosts; those that use *Q. ilicifolia* as an adventitious host, or only in part of their range; to species that occur consistently on scrub oak nearly throughout its range and are characteristic members of its fauna. In the last-named category are the phytophagous *Lygocoris semivittatus* and *Phytocoris olseni,* and the apparently mainly predacious *Ceratocapsus digitulus, C. pilosulus, C. sericus, C. vicinus,* and *Phytocoris antennalis.* Mirids that have been collected at relatively few sites but nonetheless are considered characteristic scrub oak species are the phytophagous *Plagiognathus guttulosus, Pseudoxenetus regalis,* and *Teleorhinus tephrosicola,* and the predacious *Ceratocapsus fasciatus, Schaffneria davisi,* and *S. schaffneri.* Several of these are rarely collected bugs for which biological information has been scant or lacking.

Even the most abundant or characteristic phytophagous members of the fauna probably are not restricted to developing on *Q. ilicifolia.* Most are known from *Q. rubra* and other common species of the red oak group. Oak-associated insects tend to occur on closely related hosts and thus specialize on species of the red or the white oak group (Connor et al., 1980). But several scrub oak Miridae also develop on *Q. prinoides,* a shrubby oak of the subgenus *Lepidobalanus,* when it coexists with *Q. ilicifolia* in certain pine barrens, or they develop on canopy oaks of the white oak group. A higher percentage of oak mirids appears to cross subgeneric lines than do leafmining microlepidoptera (Opler, 1974a, b), leafmining weevils (Connor et al., 1980), or gall wasps (Cornell and Washburn, 1979). Mirids probably are less host specific because even mainly phytophagous species are opportunists that engage in facultative predation (e.g., Wheeler, 1976) and scavenging (e.g., Wheeler, 1971).

Although plant bugs characteristic of scrub oak were present at most sites, faunal composition varied among the pine barrens inventoried. As Strong et al. (1984) emphasized, no colony of a particular plant can be expected to harbor all phytophagous species known to be associated with that plant throughout its range. In their words, "Local communities of phytophagous insects are a variable subset drawn from the regional pool of potential colonists. . . ." Scrub oak not only possesses a rich phytophagous mirid fauna but is a host of numerous predacious species. Composition of this predatory fauna presumably is influenced by the presence and density of canopy oaks and other hardwoods occurring in pine barrens.

Faunal composition at Frackville, the only pine barren sampled regularly, changed as the season progressed. Mirids specializing on staminate catkins, or at least appearing to feed extensively on this temporary resource, were among the first to appear. Egg hatch of the univoltine *Lygocoris semivittatus, Plagiognathus guttulosus,* and *Pseudoxenetus regalis* occurred in late April or early May before vegetative bud break. Eggs of the univoltine predator *Deraeocoris quercicola* also hatched before leaves unfolded. Although early-season collections may yield only three or four species, it is possible to collect 15 to 20 species at a given time during July or August. In Maine's contiguous Shapleigh and Waterboro barrens, 22 species were taken during portions of three days in early August. Predacious mirids such as univoltine *Ceratocapsus* spp. and bivoltine *Phytocoris* spp. tend to dominate late-season collections.

An analysis of mirid distributional patterns, including origin of the fauna, is premature because of inadequate sampling of northeastern pine barrens and similar communities, and because of a fragmentary knowledge of mirid distribution in North America. Table 1 suggests that the fauna of the communities sampled corresponds somewhat with the major pine barrens variants: boreal, inland midlatitude, coastal, Poconos, and unclassified. Several species of more southern range that are known from the New Jersey Pine Barrens and Long Island barrens, e.g., *Phytocoris olseni* and *Teleorhinus tephrosicola,* were found in the Albany Pine Bush. Some Lepidoptera reach their northern limit at Albany (Schweitzer and Rawinski, 1986), as do certain amphibians and reptiles (Stewart and Rossi, 1981). *Phytocoris olseni* and another species of apparent southern range, *Ceratocapsus rubricornis,* occur in the Myles Standish State Forest, a coastal barren in Massachusetts. Presence of *P. olseni* in the northernmost major pitch pine-scrub oak barren, Maine's Fryeburg Barrens, however, was unexpected.

No remarkable boreal elements were present in Maine barrens; this may reflect lateness of the collecting, but a scarcity of northern species of Lepidoptera also is typical of Maine pine barrens (Widoff, 1987). Two mirids of northern range, *Noctuocoris fumidus* and *Phytocoris lasiomerus,* were collected in Pennsylvania's Frackville Barrens; the latter species also occurred at Scotia Barrens. Schweitzer and Rawinski (1986) noted that Scotia belongs to a group of barrens difficult to categorize. The only specimen of *Eustictus necopinus* taken during the study was from Scotia, and the only *Reuteria* spp. found in Pennsylvania barrens also were collected there.

Two undescribed mirids of undetermined association with scrub oak were collected during the study. Perhaps most interesting, however, was the discovery of an aphid-ant-plant bug system that includes the myrmecomorphic *Schaffneria davisi, S. schaffneri,* and *Pilophorus furvus* as probable Batesian mimics receiving protection from predators because of their resemblance to ants. How this system functions within

the arthropod community associated with scrub oak and the possible coevolution of the mirids with ant-attended aphids are points worth investigating.

Numerous other questions remain unanswered regarding the diverse mirid fauna of *Quercus ilicifolia* in pitch pine-scrub oak barrens. What is the critical size of these ecological islands necessary to maintain species diversity? How does early-season frost damage affect plant bugs? A more crucial question concerns the effects of fire on the mirid fauna. Pine barrens organisms generally are fire-adapted, but most arboreal plant bugs overwinter in the egg stage. They could be severely affected by fire. Ant mimetic bugs such as *Schaffneria* spp. and *Pilophorus furvus* appear to depend on the presence of aphid colonies tended by the ant *Dolichoderus taschenbergi*. Fire, however, destroys colonies of this ant, and its natural rate of spread is slow (Bradley, 1972). Therefore, the presence of these poorly known, patchily distributed and, perhaps, rare myrmecomorphic mirids should be considered when prescribed burning is used to manage pine barrens.

The impressive number of Miridae occurring on *Q. ilicifolia* further documents the biodiversity associated with pitch pine-scrub oak barrens. Several plant bugs, including *Schaffneria* spp., not only appear to be characteristic of scrub oak but indicators of pine barrens or other sand scrub habitats. As such, certain mirids might serve as barometers of the health or vitality of a particular pine barren. These unique natural communities, and their associated biota, deserve to be appreciated and preserved.

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